AERO ENGINES MAGNETOS AND CARBURETORS

POLLARD

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AERO ENGINES, MAGNETOS AND CARBURETORS

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PREFACE

To the aviator of the future, this book is dedicated by the author, with the hope that it may aid in smoothing the difficulties from the path of some of those who are endeavouring to qualify as pilots. It is not intended as an exhaustive treatment of the subject of aeroplane engines, or as a technical work, nor does the author profess to be an expert authority. Every endeavour has been made to write in simple everyday language on a subject necessarily somewhat technical, so as to bring it within the capacity of the amateur.

During many years of experience with engines of the types dealt with, the writer has gathered a quantity of information valuable to the learner and publication of this has been urged upon him by those in touch with his work. It was considered

that a work of this nature would not only be helpful, but almost a necessity, to the beginner.

In presenting this work to the public, the author desires to express his appreciation to those who in various ways assisted in its compilation. The position which he at present holds unfortunately makes it impossible to publish their names at this time, but a fuller recognition will be accorded at a later date, when circumstances permit.

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AERO ENGINES, MAGNETOS AND CARBURETORS

CHAPTER ONE

INTRODUCTORY

THE eyes of the whole world are to-day turned to the Internal-Combustion Engine. The advent of gasoline, or "Petrol" as it is known in England, opened an era of development not less wonderful than that introduced by steam as a source of power. Steam made the locomotive possible, bringing the ends of the world together within limits; steam brought a thousand types of factories into being, bringing articles formerly made slowly and expensively within the reach of all classes of people.

The splendid work for mankind that the steam engine inaugurated, it would seem to be the province of the gas engine to continue. Although it is but a quarter of a century since "petrol" made its

somewhat odoriferous bow to the world at sundry exhibitions of "horseless carriages" in England and America, "gas" has ousted its older competitor from many fields of industry and created new scopes of activity suited to itself alone.

The gas engine has taken over practically all of the lighter duty, both on land and on water, leaving the heavy duty sphere alone to steam power. The automobile has retired the horse almost entirely from the cities and to a great extent from the farms. Pleasure launches, now so conspicuous a feature of every body of water, could never have become popular had they depended on steam with its bulky engine and fuel, its heat and dirt and special engineer for its operation.

Not content, however, with its conquests in the lighter duty field, the Internal-Combustion Engine has invaded the heavier duty realm, and to-day large ocean-going vessels are driven by "gas," high-powered touring cars testify to its versatility, powerful fortresses, made mobile by its aid, crawl

resistlessly over the devastated lands of France, while above all drone the aeroplanes.

Gas! Master of the Air! Conqueror of that great space that the human race has ever dreamed of subduing to its will. Above the earth, Gas is lord indeed; no other competitor has found a place there. The sacrifice of many lives of intrepid men in glider experiments established the principle of the heavier-than-air machine as opposed to the balloon type, but the high efficiency attained by the gasoline engine made heavier-than-air flight for prolonged distances practicable. It also lifted the balloon from a mere gas-bag at the mercy of aerial currents to the useful dirigible.

The need of maximum power with minimum of weight and bulk has made the aerial type of engine the highest expression of the engine designer's art. Nor yet has the limit been reached; greater power in relation to weight is constantly being obtained by the employment of new discoveries. The aeroplane year by year becomes more stable, more

speedy, and more adaptable to the requirements of peace and of war. The future of the mechanical birds of human creation has been the subject of many works of fiction, and it may be that the counterpart of that "Clipper of the Clouds," of which Jules Verne dreamed and wrote, will some day sail the skies in reality; should that day come, the internal-combustion engine will have made it possible.

To-day, thousands of young men, the flower of the civilized nations of the world, eager to win their "wings" and become masters of the upper element, are studying aeronautics in war schools. Apart from the fortunes of war, these valuable lives are dependent on their knowledge of their machines and more particularly, perhaps, of the engines. These engines are of many types and special functions, their mechanism, to the embryo aviator, perhaps new from the desk or the farm, is a "terra incognita," and delivered in the form of lectures, apt to leave the mind confused. To

aid these young students to overcome their initial difficulties and give a general conception of the principles of the internal-combustion engine as used in aeronautical spheres, is the object of this work.

CHAPTER TWO

ENGINES

A GASOLINE engine, or in fact, any engine which is operated through the medium of exploding a gas inside a cylinder, is known as an Internal-Combustion Engine. It can easily be seen from an inspection of the accompanying diagram that the essential parts of a gasoline engine are a piston and a cylinder in which the piston moves up and down; the reciprocating or up-and-down movement is accomplished through the medium of a connecting rod which is attached to a rotating crankshaft. Two valves are fitted, one the inlet valve, for the admission of the gases to the cylinder — this gas being supplied by an instrument known as a carburetor — and the other, known

as the exhaust valve, to allow of the spent gases getting away from the cylinder. The valves are operated through the medium of tappet rods, these in turn being operated by fixed cams on a rotating camshaft. A sparking plug is also fitted, which is connected to a high-tension magneto, producing an electric spark for the ignition of the gases in the combustion chamber. The combustion chamber, of course, is the space between the top of the piston and the cylinder head.

THE CYCLE OF OPERATIONS

To explain the action of a gas engine makes necessary an analysis of what is known as the "Cycle of Operations." All the aero engines of note to-day are engines working on the four-stroke principle, or the Otto Cycle. This is a cycle of four strokes in the following sequence — Induction, Compression, Power, and Exhaust, each stroke being of equal duration. This is, of course, only a theoretical cycle and in practice is never ad-

hered to. It is the reason for the practical points of variation in this cycle that it is necessary to deal with.

Commencing with the Induction stroke, the piston is in the Top Dead Centre position, by which is meant the highest point the piston reaches inside the cylinder. As the piston descends on the Induction stroke, the inlet valve opens, simultaneously admitting a mixture of gasoline vapour and air into the cylinder. This is continued until the piston is some little distance past the Bottom Dead Centre; that is, the piston is in its lowest position in the cylinder. The inlet valve is caused to close when the piston has ascended a little way on what is really, theoretically speaking, its compression stroke. This is a common point of closing on all internal-combustion engines and ensures a full charge of gas being admitted into the cylinder. It is found that the piston descends with a greater velocity than that of the incoming gases, so that were the inlet valve to close at the bottom

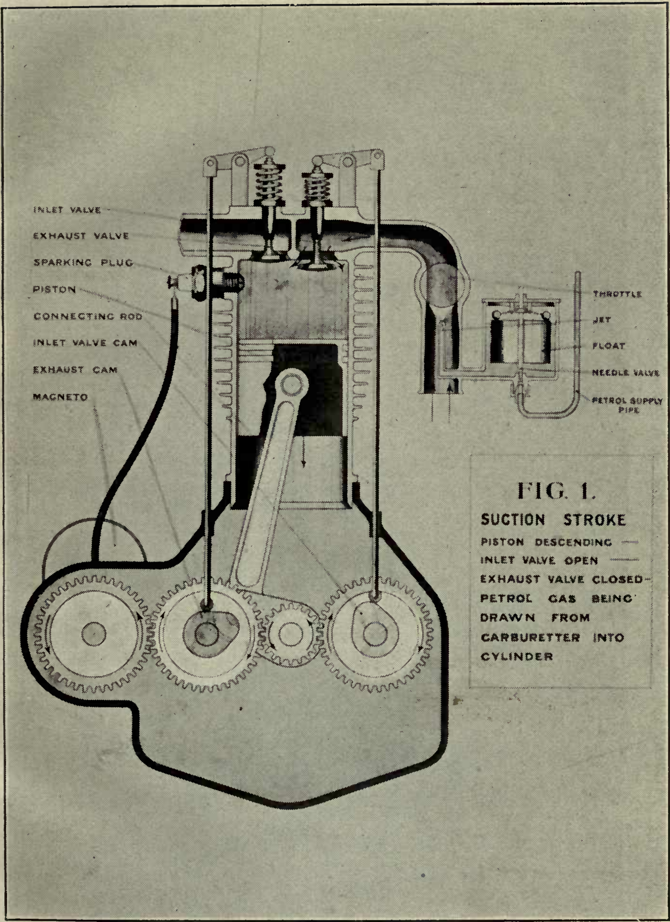

Fig. 1. — Diagram illustrating the Induction or Suction Stroke.

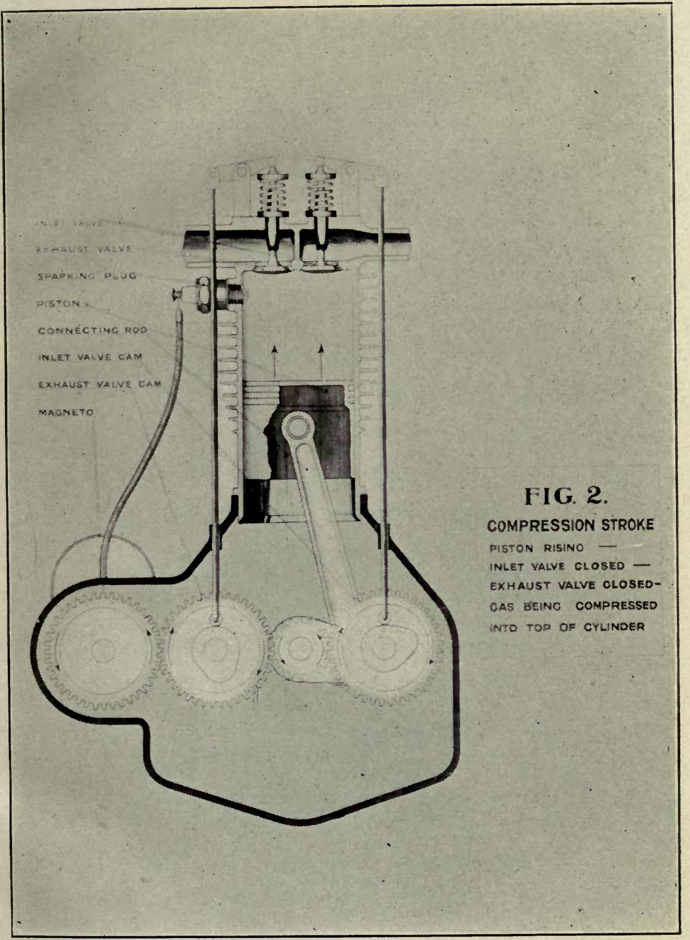

FIG. 2. — Diagram illustrating the Compression Stroke.

dead centre, its true theoretical point for closing, there would be a shortage of gas in the cylinder and consequent weak compression and loss of power.

From the point of inlet closing until top dead centre is again reached is what is known as the Compression stroke, the gases being compressed to a pressure of approximately 85 to 95 pounds per square inch. It is a well-known fact that in compressing a gas the temperature is raised, therefore heat is given to the gases in the cylinder. Care then has to be taken in the design of an engine that the pressure of compression shall not exceed the figures stated, otherwise there would be a possibility of spontaneous combustion.

It will be noticed that ignition occurs before top dead centre. The reason for this is to allow of the whole of the gases being fully ignited before top dead centre is reached. This is what is commonly known as having an advanced position of ignition. To retard the point of ignition means

to carry the point of ignition nearer to the top dead centre. In a like manner, advancing the ignition would be to make the point of ignition at an earlier period of the stroke.

From the top dead centre the piston descends on the Power stroke. Some little distance before bottom dead centre is reached, the exhaust valve opens and it remains open for the full exhaust stroke, which is completed when the piston has again reached top dead centre. This point of exhaust opening is spoken of as "Exhaust opening so many millimetres or degrees early." It is a common impression that this early opening of exhaust is to ensure the gases being thoroughly clear from the cylinder before the commencement of the next induction stroke. Another rather general idea is that it is to relieve the back pressure on the piston as it ascends on the exhaust stroke. While both of these reasons are quite correct, the most essential reason for opening the exhaust early is to permit of cooling.

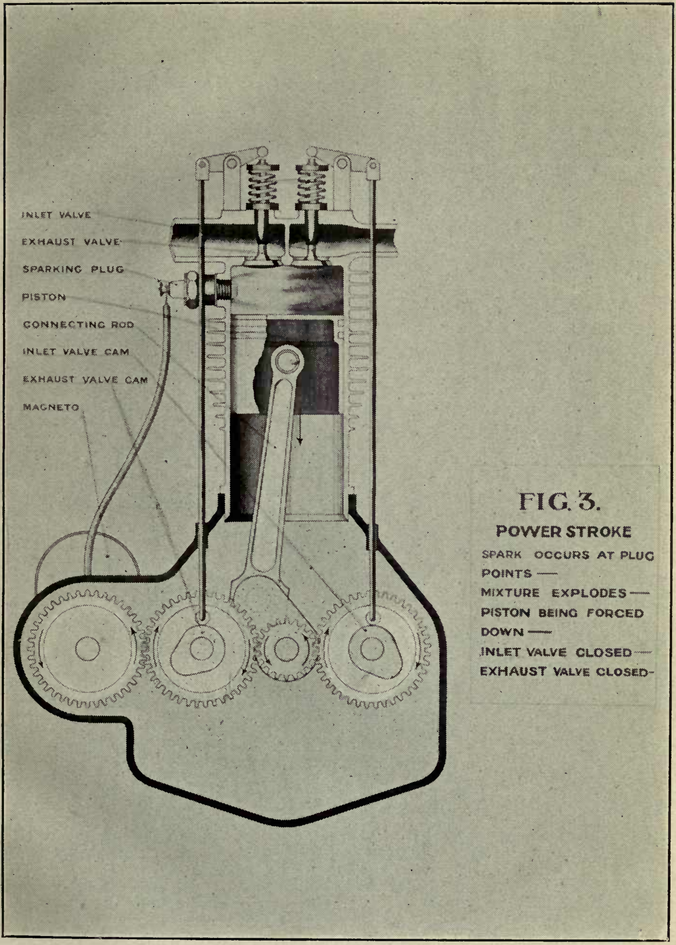

FIG. 3. — Diagram illustrating the Power Stroke.

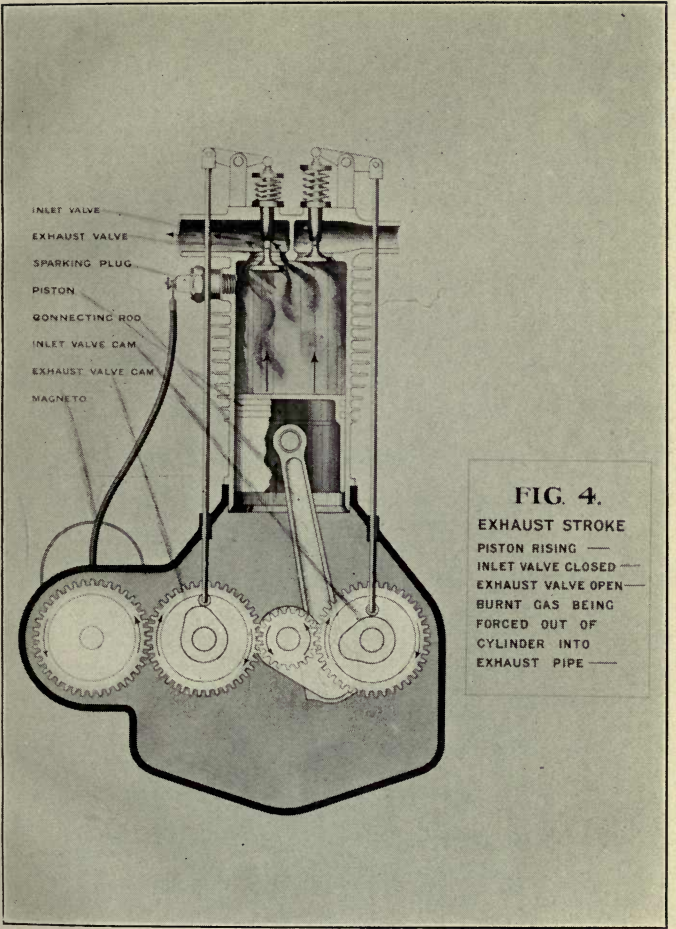

Fig. 4. — Diagram illustrating the Exhaust Stroke.

As the gases expand in the cylinder, so their temperature is reduced. This, of course, means an abstraction of heat which is absorbed by the cylinder wall and ultimately gives rise to an increase of temperature of the cylinder wall. Now it is a well-known fact that an overheated engine does not run as well as a cool one, and, up to a certain point, were expansion to continue to a later point in the stroke, the loss of work which would accrue through overheating would be greater than the actual work which is thrown away by opening the exhaust early.

From the point of exhaust closing to top dead centre is known as the exhaust stroke, thus completing the cycle.

This brief description of the Cycle of Operations for an internal-combustion engine applies generally to all types working on a four-stroke principle, and emphasizes the great care that must be exercised in the setting of the valves.

ENGINE TYPES

Engines in general use to-day can be classified under three headings, — Stationary or reciprocating, Rotary, and Radial. Stationary engines, such as the Hispano-Suiza, Rolls-Royce, Sunbeam, and Beardmore, have their cylinders set at an angle and situated above the crankcase, or are vertically above the crankcase, as in the case of the Beardmore or Sunbeam. In all cases, the crankcase and cylinders are stationary, the crankshaft revolving.

In the Rotary type, the cylinders are set radially around a fixed crankshaft, the cylinders and crankcase revolving. Examples of this type are the B. R., Le Rhone, Clerget, and Monosoupape.

The Radial engine is in appearance very similar to the Rotary, having its cylinders set in like fashion around the crankcase, but they are stationary and are usually water cooled, the crankshaft itself revolving. An example of this type is the Canton-

Unne. The Radial type will be but little referred to, as it is only used in small numbers.

THE ROTARY ENGINE

The Rotary engine, being the most important from an aviation standpoint, requires further description. What is the principle governing its operation, or in other words, why does it revolve? On examination of the diagram it is found that in any Rotary engine there are two centres of rotation, *A* being the centre of rotation for the pistons, around which the pistons revolve at a fixed radius, *B* the centre point around which the cylinders and crankcase revolve. The distance between these two centres is approximately half the stroke of the piston.

The diagram shows a piston in a slightly exaggerated position of explosion. The point *C* represents the gudgeon pin and the arrow *P* represents the thrust on the piston head due to the explosion of the gases in the cylinder. When

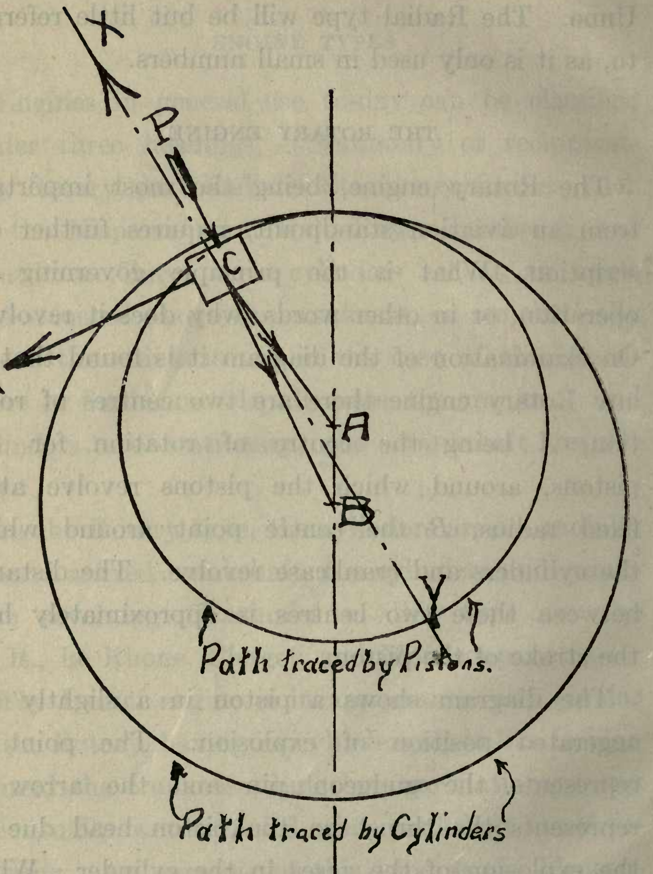

FIG. 5. — Diagram illustrating the Working Principle of a Rotary Engine.

an explosion occurs, the force P is exerted in the direction of C to A. This, of course, is due to the fact that the pistons are connected to the point A through the medium of the connecting rod. There is also another force in the direction C to B set up, due to the fact that the piston is trying to reach the point B, because it is guided in the cylinder which is set radially to the centre B. Now it is well known to students of mechanics that wherever there is action, there is reaction equal and opposite, consequently there will be the reactions of two forces, CA and CB, and the resultant, shown by the line XY, is resolved into the force R on the leading edge of the cylinder, causing the engine to revolve. This principle only applies to a Rotary engine and not to the Radial engine, which is very similar in outward appearance.

COMPRESSION

Leaving the general principles of engines, some of the more important details will be dealt with.

Of very great importance is the Maintenance of Compression in an engine. Compression is maintained through the medium of well-fitting valves, piston rings, and accurately made joints, such as the joint between the cylinder and body, sparking plug and its mounting.

The maintenance of compression must not be confused with the keeping of a piston gas-tight in its cylinder. It has been found from experience that many people have a doubt as to what answer one should make to the question: "How is a piston kept gas-tight, and how is compression maintained?" Pistons are made gas-tight by the fitting of piston rings or their equivalent, and compression is maintained as stated above. Oil does not maintain compression as so many are apt to think; it certainly does assist to a slight degree, and the addition of more oil or a thicker oil may appear to raise the compression of the engine, but it will ultimately lose power through the overheating which will follow from over-lubrication.

VALVE OPERATION

Practically all the valves on aero engines are mechanically operated. In some cases, they are operated through the medium of an overhead camshaft; in others, by means of a tappet lifting up a tappet rod, which in turn depresses the valve. In between this tappet and tappet rod there is a small space of a few thousandths of an inch which is spoken of as "tappet clearance." This clearance is to allow of the expansion which occurs after the engine has become heated; if it were not there, after a little while the tappet and the tappet rod would have expanded to such an extent as to cause the valve to remain permanently open. It can easily be seen that this clearance, if altered to any large extent, will materially affect the lift and the length of time the valve is open, and consequently, in a very large degree the efficiency of the engine. It will require no very large amount of perception on the reader's part to grasp this fact, and that

tappet clearance is not for the purpose of retarding or advancing ignition, as its functions have been misdescribed more than once by would-be aviators.

THE CRANKSHAFT

The next point to claim attention is the function of the crankshaft and the camshaft on rotary and stationary engines. On a stationary engine, the chief duty that the crankshaft has to perform is to transmit the power given to it by the pistons to the propeller which it is driving. In the case of a rotary engine, the crankshaft has many more functions to perform. The following list gives a rough idea of the many and varied functions of a rotary engine crankshaft:

1. A point of attachment for the engine to the plane.
2. A point for the pistons and cylinders to revolve around.
3. A point of attachment for the carburetor.

4. The whole of the thrust from the propeller is absorbed by it.
5. It conveys oil to the working parts.
6. The crank pin provides a fixed point against which the force of the explosion can exert itself in revolving the engine.

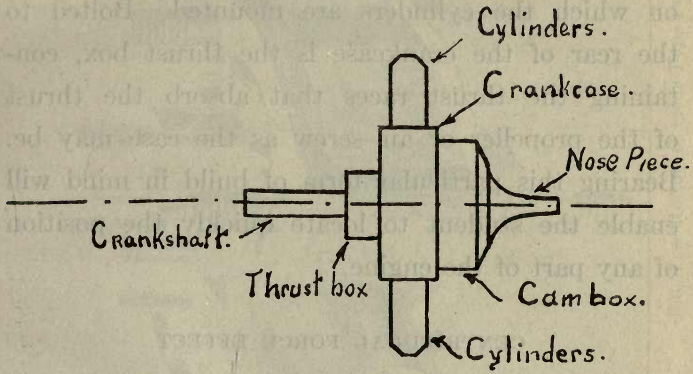

FIG. 6. — Diagram illustrating Sequence of Build of Rotary Engine.

It will be noticed that the crankshaft functions partly as a camshaft, inasmuch as the small end forms a pivot around which the campack rotates.

In studying rotary engines, it is as well to bear in mind that the following sequence of build is

general throughout all the different types. Starting from the front, or propeller end of the engine, and passing to the rear, the build is as follows: The propeller boss is mounted on the nose piece which is attached to the front of the cam box, this in turn being held to the front of the crankcase on which the cylinders are mounted. Bolted to the rear of the crankcase is the thrust box, containing the thrust races that absorb the thrust of the propeller or air screw as the case may be. Bearing this particular form of build in mind will enable the student to locate quickly the position of any part of the engine.

CENTRIFUGAL FORCE EFFECT

Centrifugal Force plays an important part in a rotary engine. Any body which is influenced by this force tends to fly outwards in a radial direction. A very well-known illustration is the swinging around of a bucket half full of water, centrifugal force in this case throwing the water firmly

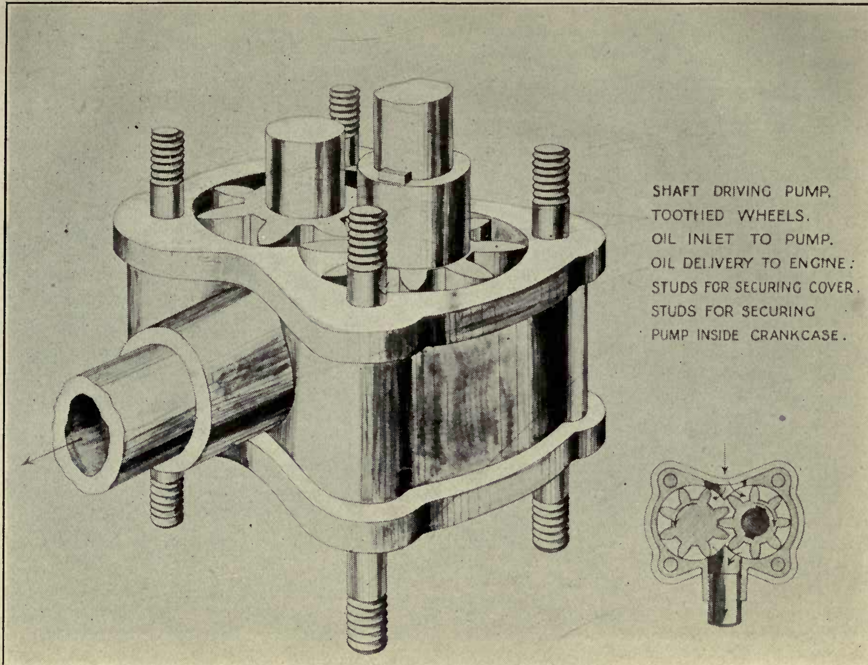

FIG. 7.—Rotary or Gear Type Pump.

against the base of the bucket and thus preventing the water spilling.

When a truly formed and well-balanced flywheel rotates at a moderate speed no vibration is apparent. Should, however, any portion or section of the rim of this flywheel be heavier than the remaining portions of the wheel, the centrifugal force affecting it will produce an internal stress on this portion, and will ultimately cause that part of the wheel to break away if the wheel is only revolving at a moderate speed; also an acute vibration will be present, due to the unbalanced flywheel. This effect is very easily demonstrated by a simple little experiment with a disc which has three bolts attached in a symmetrical manner around the circumference; when this disc is rotating, no vibration is present, but upon removing one of the bolts and throwing the disc out of balance, an acute vibration is shown. This is, of course, only a general illustration.

Take a particular case — the exhaust valve on the

Le Rhone engine. When this engine is revolving at moderately slow speeds, the exhaust valve closes at forty degrees before top dead centre, while at the normal rate of revolution for this engine the exhaust closes five degrees past the top dead centre. The reason for this is that mechanically the valve closes at forty degrees before top dead centre, but owing to the influence of centrifugal force at high speeds the tappet rod is hurled outwards, thus depressing the exhaust valve and keeping it open until five degrees past top dead centre. Similarly, in the case of the Monosoupape engine, the exhaust valve is made much heavier than mechanical strength demands of it, purely to counteract the influence of centrifugal force on the tappet rods. Thus, by making the valve heavier, the necessity of having to fit balance weights to the tappet rod, as is done in the Gnome, is obviated.

From the particular examples given, it is apparent that it is absolutely essential, in replacing any part of an engine which is affected by centrif-

ugal force, that the weight of the new part should be of equal weight with the one it is replacing.

ORDER OF FIRING

The different orders of firing which prevail have a marked effect from a balance point of view on the various types of engines. The order of firing on an eight-cylinder "V" type engine, say, is 15374826. On examination, it will be seen that the cylinders are firing with an interval of time equivalent to a quarter of the stroke; therefore, taking two successive cylinders, the impulses on the crankcase from the explosions occur almost simultaneously. A similar condition exists over the remaining six cylinders, giving a common point of intersection over the complete order of firing. This common point of intersection of the different impulses is approximately over the centre of gravity of the engine. By having the force of explosion localized at the centre of gravity, a minimum vibration is

produced. This order of firing gives a maximum balance with a minimum vibration.

In contrast to the preceding example, take an engine of exactly similar type, but with a wholly different order of firing, say, 12347856, and with the cylinders numbered as shown on the sketch. When this engine is running, there is a tendency to rock longitudinally in the plane; that is, there is a very great chance of an acute vibration being present.

The above explanation will probably be better understood by the following simple example: Take a plain table supported at each of its corners; if a pressure be brought to bear on its centre, this force will be borne equally by each of the supports and there will be no tendency towards movement, or vibration on the part of the table. If, on the other hand, the table were struck forcibly on one end, most of the pressure would be borne by the supports at that end and the table would tend to lift upwards. If the table were struck at the op-

posite end, there would be a reverse effect produced. Consequently, the alternating forces of this nature acting on the table, there is a possibility of it remaining in a state of vibration.

All rotary engines fire in one specific order, the cylinders being caused to fire alternately, a seven-cylinder engine firing in the order 1357246. Plainly, it would be impossible to fire these cylinders consecutively, or to have an even number instead of always an odd number of cylinders. If the question were asked: "What is the order of firing of a Rotary Engine and why?" the answer would be that the order of firing is 1357246 to conform to the "four-stroke" principle, giving a maximum balance and an evenly distributed turning moment.

If each cylinder had to be fired in turn, since it requires two revolutions of the engine to give four strokes, and the next revolution would be all exhaust, speed would have to be maintained purely by the excess of energy which the machine had received on the previous stroke. Thus there would

be a very erratic turning moment with this order of firing. Now take the case of an engine with an even number of cylinders. It will be seen that it is impossible for exactly the same reasons as just mentioned to fire these cylinders consecutively; also it would be impossible to fire the cylinders alternately because only half of the cylinders would be fired.

LUBRICATION

The lubrication of engines is accomplished by "force" and "splash." By splash lubrication is meant that the oil is thrown up in the form of a spray from the connecting rod big ends. These ends are sometimes fitted with a scoop which dips into a trough of oil at each stroke, thus supplying the necessary splash. In other cases, it is the excess of oil oozing from the crank-pin bearings which is picked up by the whirling crankshaft and thrown up into the interior of the cylinder, oiling cylinders, pistons and piston rings.

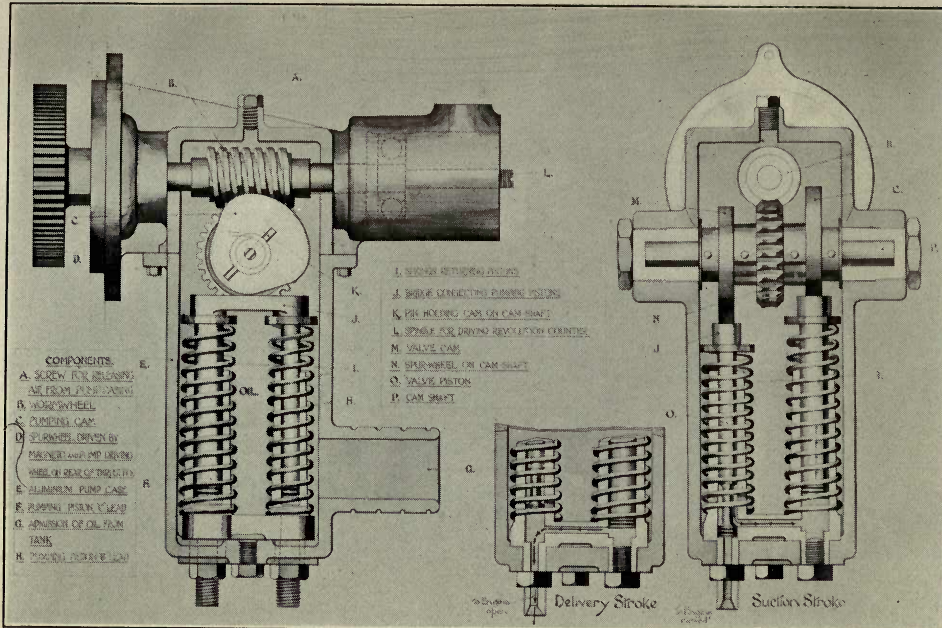

Fig. 8. — Plunger Type Pump.

Force lubrication is effected by means of oil circulating pumps, divided into two classes, Rotary or Gear type, and Plunger and Piston type. The general principle of each of these types of pumps is the same, but they are modified to a certain extent to meet the varying designs of engines. The most elementary form, and one which is very largely used, is shown in the illustration; it consists of two small gears which engage with one another and run in a close-fitting casing. Oil enters midway at one side of the casing and leaves similarly at the other side of the pump. The oil is transmitted by the spaces in between the teeth, which form, as it were, small pockets for the oil. Oil is carried around both sides of the casing as shown by arrows, the teeth at the point of engagement at the other side of the casing forming an oil lock.

The lubricating systems that prevail on the various engines, and particularly their methods of adjustment, require some explanation. In the case of the R. A. F. engine, no mechanical means are

provided for adjusting the flow of oil through the engine. It can, however, be regulated at three different points. The flow can be controlled in a general way by adjusting the by-pass, which is to be found in the form of a rectangular plate with a slot in it, which acts as an overflow to the oil, which is collected from the supply delivered by the flywheel. By adjusting the size of the slot, the amount of flow to the engine can be varied, thus giving a smaller or larger delivery of oil to the engine as the case may be. The oil supply in this engine can also be adjusted in a smaller and more defined degree by adjusting the plates that are fitted over the oil pipes to the second and fourth crankshaft bearings. Finally, the oil supply can be regulated locally to each cylinder in turn by drilling the cylinder baffle plates.

In the case of the Beardmore engine, there is provided, through the medium of the pump, a definite and accurate means of adjusting the oil supply at six definite points. By altering the

stroke of the plungers, the amount of oil to any part of the engine can be either increased or decreased by a definite quantity.

It would be well, while dealing with lubrication systems, to say a word or two regarding the different lubricants used. On a rotary engine, in every case, a vegetable oil, such as castor oil, or Castrol, is used. The reasons for this are that a vegetable oil does not easily mix with petrol; also, it has a higher flash point and a higher viscosity, or, in simpler language, it is more sluggish in action. There is one point to be guarded against in the use of a vegetable oil, especially in the cold months of the year: Castrol oil when allowed to stand for any length of time on a cold day will deposit a sediment at the bottom of the vessel in which it is held, and the oil will become very much thicker. To thin Castrol oil, so that it would again become serviceable, it would be necessary to heat the oil and at the same time stir it well to get the sediment back again into solution. If the sediment were

allowed to go into the engine, it would have a very detrimental effect on the bearings. Another way of rectifying this trouble is to mix fifteen per cent of Methylated Spirit with the castor oil. Mineral oil is used on stationary engines only.

COOLING SYSTEMS

To maintain the engine at a workable temperature, a system of cooling is adopted. This may be either by water or by air. In the case of water, the fluid circulates around the cylinders, the heated water passing back through a radiator where it loses considerable of its heat. The cooling is assisted by passing the water through thin copper tubes, surrounded with radiating flanges of thin metal, offering the largest possible cooling surface to the air. Further aid to cooling is provided by placing the radiator in the foremost part of the machine, the current of air formed by the speed of the machine materially helping the process.

Both water and air systems are used on stationary engines, the former, however, being the more efficient, there being less overheating. On air-cooled engines, the fins are solid with the cylinder to give a greater area of cooling surface. This is true in the case of rotary engines, which are air-cooled, but in addition to this, there is a polished surface on the cylinders which gives a greater radiation. It is a well-known fact that a bright surface will radiate heat at a much quicker rate than a dull or unpolished surface.

A disadvantage in connection with the cooling of a rotary engine is that the leading edge of the cylinder is much cooler than the trailing edge; this gives a difference of temperature around the cylinder walls, producing a distorted cylinder and so necessitating the use of a special type of piston ring which is known as an obdurator ring. This type of ring is fitted because it will easily follow the distortion of the cylinder, thus keeping the piston compression tight in the cylinder.

The accompanying sketch shows an enlarged view of the obdurator ring as it is supplied from the stores. It will be noted that the four corners marked *A* are perfectly square. If the ring

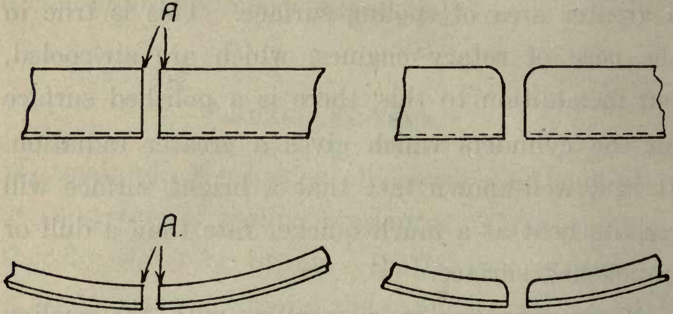

FIG. 9. — Illustration showing how an Obdurator Ring Joint should be made.

were fitted to the piston and these corners left square, however well a ring may be fitted and the gap adjusted accurately, it would very quickly become burnt at the points, due to the fact that all the heat from the explosion would tend to flow to this point. To obviate this, when fitting a ring, the corners *A* should be rounded as shown in Figure 9. By performing this small operation, the life

of the ring is very materially increased. This point should not on any account be neglected or belittled by the fitter.

A comparison of air- and water-cooled engines shows that the advantage of a water-cooled engine is longer life and a higher thermal efficiency, due to a smaller loss of work from overheating. The disadvantages attached to a water-cooled engine from an aeronautical point of view is that it is much heavier and also that there is a possibility of trouble due to the freezing of the water. The latter can be prevented to a very large degree by adding glycerine to the water in the proportion of 1 to 5.

As regards the advantages of rotary over stationary engines, the chief advantage of the former is that its weight per horse power is much less. It is easier to dismantle a rotary engine and it is more accessible. The disadvantages of the rotary engine are that it is a very heavy consumer of fuel, and not as reliable as the stationary engine.

CARBURATION

Carburation has a great effect on the balance of an engine. If the gas supplied to the cylinders is evenly distributed and of the same strength to each cylinder, then there would be a well-balanced engine from a carburation point of view. In some engines, one carburetor is fitted to supply perhaps eight cylinders, thus allowing a cylinder that is stronger in compression to rob to a slight degree one that is weaker in compression. This trouble is partially obviated on engines such as a six-cylinder vertical engine, where only three cylinders are fed from one carburetor. This point will be dealt with more fully in the chapter on Carburetors.

TIMING

It has been stated in a previous chapter that all the engines at present in use are worked on a common basis; *i.e.* the four-stroke or Otto-cycle principle. Since this is so, one method for the valve timing of these engines is applicable in every case,

no matter what the design of the engine may be. It consists of the performing of a sequence of five operations, which can be tabulated as follows with timing gears unmeshed:

1. Set any piston in exhaust closing position.
2. Set the exhaust tappet clearance for that cylinder.
3. Turn the camshaft in the direction of rotation until the particular exhaust valve for the cylinder being timed is in the closed position.
4. Now mesh the timing gears.
5. Adjust the remaining tappet clearances.

Similarly, the ignition timing of any engine can be accomplished by:

1. Set any piston in ignition position.
2. Mesh the magneto driving gear with the platinum points on the contact breaker just open.
3. Wire the distributor terminals to the sparking plug terminals in the correct order of firing.

RUNNING THE ENGINE

Having dealt with the main principles governing the working of an Internal-combustion engine, the running of an engine before a flight demands some attention.

There are several points in the running of an engine before a flight, and on the ground again after a flight, that require careful attention and should be very closely observed by the pilot. The points to pay particular attention to before a flight are arranged in the following order according to their degree of importance:

1. See that the switch is off and wired up correctly so as to prevent the possibility of accident should the propeller be swung or moved in a thoughtless manner by any one in the vicinity of the machine and also to ensure the certainty of your engine responding to the movements of the switch.
2. See that there is enough petrol and oil for the

flight about to be made, so as to avoid the unpleasantness of a forced landing through lack of fuel or engine becoming excessively overheated.

3. Feel the tappet clearances, so as to guard against the possibility of a valve remaining open or the engine losing power through too small a clearance.
4. Feel the propeller for security on its shaft, and inspect in a general fashion all nuts and bolts that are responsible for securing the engine in the plane.
5. Revolve the propeller slowly, feeling the compression of each cylinder in turn, and by so doing obtain a rough idea of the condition of the rings, valves, and joints for each cylinder.

Although the above method of procedure seems a very long, tedious and unnecessary mode of preparing an engine for a flight, it requires only a few minutes to perform the whole of the operations,

and the confidence gained at the end of such a tour is undoubtedly a great asset to the aviator.

The length of time which an engine should be run on the ground before a flight is one that can only be decided by experience. It varies, of course, with the natural elements and the design of the engine. The reason for running an engine on the ground before flight is to allow the initial expansion of the engine to take place gradually. No sudden strain is then produced on the fibres of the metal parts of the engine and as the machine ascends into the air, at which time the engine is giving its maximum power, there is no possibility or fear of causing a cylinder or holding-down bolt to break, due to the sudden loading and strain on the engine.

Other reasons for running the engine on the ground are to allow of the oil being thoroughly circulated, and, in the case of a water-cooled engine, to allow of a circulation of water through the engine. It will be seen that a specific time for the running of these engines before a flight cannot be fixed,

but the pilot must be guided purely by the force of circumstances.

After a flight, in a like manner, see that the switch and petrol are turned off and examine the engine generally for any breakages or undue signs of overheating.

TROUBLES

The only matter now remaining to be dealt with in this chapter is that concerning the troubles which may become apparent during the testing of an engine. The easiest method of locating a trouble is by a process of elimination. To an experienced man, the rhythm or hum of an engine when working is as the tune of the strings to the violinist, satisfactory when in harmony, but the slightest discord telling him the cause of the trouble behind.

Generally speaking, engine troubles may be classified under one of three headings, Carburation, Valve Timing and Ignition, Lubrication. Troubles under the first heading will be found to affect the engine in a general manner; that is,

the engine suffering from faulty carburation would stop gradually. Ignition troubles have the effect of stopping an engine suddenly. Troubles under the last heading, Lubrication, cause overheating, loss of revolutions per minute, and the possibility of ultimate cessation.

In closing, it would perhaps be of advantage to give a few typical examples of a few troubles experienced with aerial engines and their causes.

1. **Engine stops suddenly. This is due to failure of the ignition circuit.**
2. **Engine stops gradually and misfires:**
   a. Petrol used up.
   b. Carburetor choked.
   c. Petrol tank airbound.
   d. Sparking plugs fouled through over-lubrication.
3. **Loss of power, engine continuing to fire regularly:**
   a. Loss of compression.
   b. Faulty mixture.

c. Inefficient lubrication.

d. Incorrect tappet clearance, affecting the lift of the valve.

4. **Loss of power, engine continuing to fire irregularly:**

a. Magneto trouble.

b. Sparking plug or high tension wires damaged.

5. **Hissing sounds from the engine:**

a. Broken sparking plugs.

b. Leaky joints.

c. Pitted valve seatings.

6. **Engine continues to fire without being switched off:**

a. Excessive carbon deposit.

b. Switch wired wrongly, keeping engine on permanent contact.

7. **Vibration — unbalanced engine:**

a. This may be due to an incorrectly fitted cylinder, or component part which is of incorrect weight; this applies particularly

to rotary engines. A bent crankshaft will also cause the same trouble.

b. Loss of engine fittings.

c. Unbalanced propeller.

CHAPTER THREE

Carburation

Before going into the study of Carburetors and Carburation, it is necessary that one should understand the meaning of the word Carburetor. In a standard dictionary it is described as being that part of a petrol engine in which petrol vapour is carbonized. It would have been more correct and more easily understood had this definition been modified and expressed as "that part of a petrol engine in which air and gas are mixed to form an explosive mixture." The carburetor was not designed for use as a foot rest for the observer, as defined by several aspirants to fame in the fields of aviation.

In order that an engine shall work thoroughly from a carburation point of view, it is necessary

that the carburation shall remain constant throughout all engine speeds and for all positions of the throttle. This is essential for the flexibility of the engine. It is also necessary that the engine should start easily when cold and that the fuel consumption should be as low as possible. The latter requirement is most important, as the weight of fuel to be carried for a flight of five or six hours' duration will be very materially increased through lack of efficiency in this point.

Energy can be obtained from gasoline or other easily volatilized fuels by converting them into vapour and mixing them with large quantities of air. It is this explosive mixture that is used as a means of producing power in a gas engine. The method of producing this explosive mixture is by passing the gasoline through a spray or small jet into a vaporizing chamber, where it mixes with air. The gasoline is drawn out of the mouth of the jet during the induction stroke of the engine.

Gasoline is one of the hydrocarbon series of

compounds and consists of hydrogen and carbon in certain definite proportions. The best explosive proportions of gas to air range between one to eighteen and one to twenty parts. The air which is mixed with the gasoline vapour is itself a mixture of approximately one part oxygen gas and four parts of nitrogen gas, by volume. Nitrogen being an inert gas, only the oxygen combines with the gasoline vapour. The products of combustion consist of water, in the form of steam, nitrogen gas and carbon dioxide gas; these comprise the exhaust gases.

If one could look over the history of carburetors, he would find that the earliest type of carburetor consisted of a plain jet screwed into the induction pipe. As the air was drawn up the induction pipe by the suction of the engine, a certain amount of gas was drawn with it, and this mixture was passed into the engine to generate power. This method made the engine very hard to start, and exceedingly bad from an acceleration and effi-

ciency point of view when running at high speeds. The higher the speed, the richer became the mixture, resulting in overheating. It also made the fuel consumption very high. It will thus be seen that an efficient carburetor must be able to supply to an engine a rich mixture to permit of easy starting and an even mixture at all speeds to ensure even acceleration and low fuel consumption.

Since, for the efficient running of an engine, the carburation should remain constant, or in other words, since the ratio of gas to air should remain constant, the perfect engine would have the same strength mixture at the commencement of the run as at the highest speed. This is illustrated by a study of graph No. 1. This graph shows a perfectly straight line, and it is the aim of engine builders to reach this acme of perfection in carburation. It will be seen, however, from a continued study of this chapter, that although this point of efficiency has been approached, it has not yet been attained. If a series of readings

could be taken, showing the volume of gas issuing from the mouth of the jet of the carburetor at varying speeds, and the amount of air passing into the mixing chamber, thus giving the ratio of gas

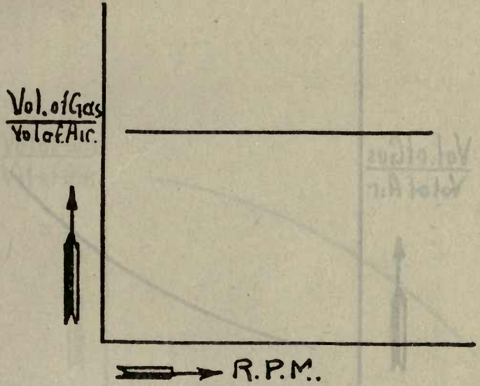

FIG. 10. — Graph No. 1.

to air at these speeds, and these be plotted, the curve would be obtained as shown in graph No. 2. From an inspection of this graph, it is obvious that the mixture delivered to the engine at low speeds is weak in gasoline, varying throughout the acceleration period, and rich at high speeds.

These conditions are all against efficiency and explain the reason why fake methods had to be adopted to start the old type engine, owing to its own inability to draw in sufficiently rich mix-

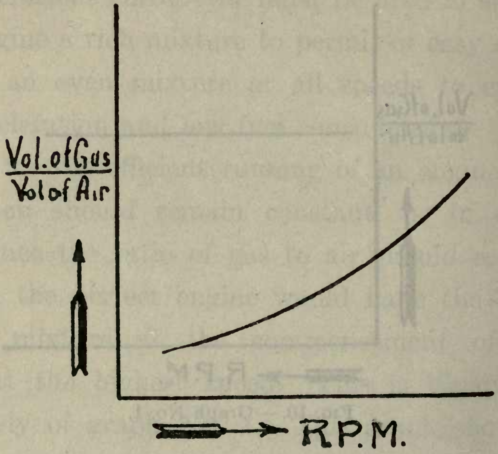

FIG. 11.—Graph No. 2.

ture for starting purposes. This state of affairs exists in many engines to-day; owing to the design of the carburetor, they are unable, without outside assistance, to furnish a rich enough mixture for starting.

There are carburetors, however, in existence which give a very near approach to perfect carburation — those fitted with compensating jets. In the carburetor of ordinary construction, the

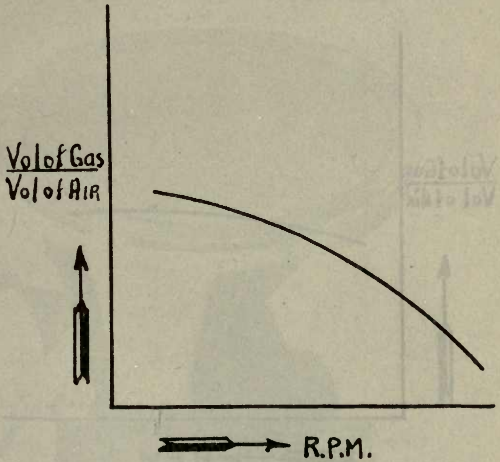

FIG. 12. — Graph No. 3.

air and petrol flow through their respective passages at rates not proportionate to the speed of the engine. This is due to inertia effect, which is more fully defined in graph No. 2. The effect of a compensating jet on a carburetor is that of

a neutralizing device, because it produces a similarly shaped but downward curve in decreasing ratio to the increasing speed of the engine. Such a curve is illustrated in graph No. 3.

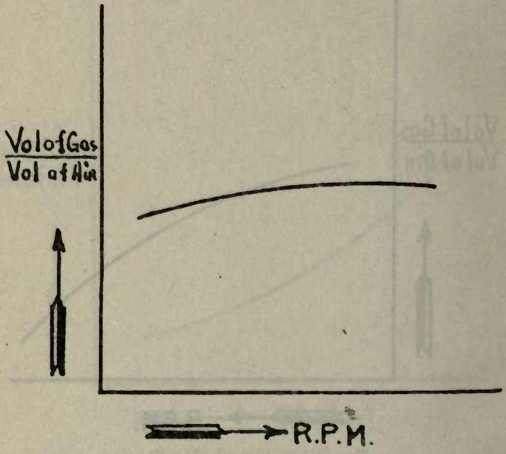

FIG. 13.—Graph No. 4.

Obviously, when any carburetor is fitted with two jets, a plain and a compensating, working in unison, the graph obtained will be the resultant from graphs 2 and 3, as illustrated in graph No. 4.

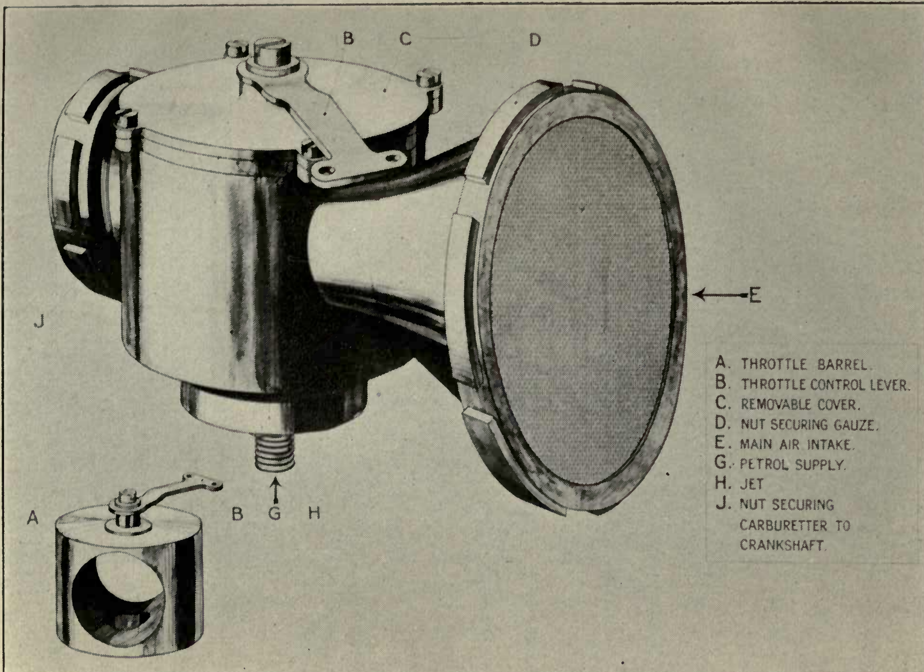

FIG. 14. — Illustration of an Early, Non-float Type Carburetor.

An inspection of this shows that perfect carburation has very nearly been reached.

CARBURETOR TYPES

Carburetors as a class can be divided into two sections — float type and non-float type carburetors, or the block-tube type, the latter being used exclusively on rotary engines. The Claudel-Hobson type may almost be termed the father of all float type carburetors, because so many points of design in this are to be found in all other float type carburetors. To have mastered fully the principles of the Claudel-Hobson carburetor is to have made great strides towards the understanding of the other types.

Gasoline enters the base of the float chamber past a filter and needle valve into the float chamber. As the level of the liquid rises, so a hollow cylindrical body known as the float rises on the surface of the liquid and when it has reached a predetermined height, two small balanced weights

are lifted, which causes the needle valve to return to its seating, thus cutting off the supply of gasoline. As the gasoline is used up, so this float falls, the valve is lifted and gasoline again enters the chamber. Thus the regulation of the flow of petrol from the carburetor and the height of the float chamber are automatically effected. Air is drawn in and as it passes the mouth of the jet, so gasoline is drawn out and the mixture then passes up the induction tube into the engine, the amount being regulated by what is known as a throttle, which is really a circular barrel fitted to the mouth of the mixing chamber in the carburetor.

On an aero carburetor of the above description, there are fitted two controls and one adjustment; the two controls being a throttle to regulate the speed of the engine and an air flap which controls the admission of air. The adjustment is in the form of a small screw known as the fine-air adjustment screw.

Taking a section of a carburetor across the line *AB* would give a figure as shown in the accompanying sketch. The shaded portions show the area into which air drawn through the air intake passes into the mixing chamber of the carburetor. It is obvious from inspection of the section that

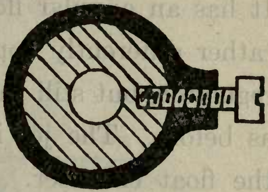

FIG. 16. — Section on line *AB* in Fig. 15.

according to whether the screw is drawn out or pushed in, so will the area be greater or smaller, thus varying the strength of the mixture. On examination of the actual carburetor, this may not appear to be of great importance, but it has a marked effect on the running and the efficiency of the engine.

THE BEARDMORE

A few words on the salient points of the Beardmore carburetor may be of use to the student. This carburetor has one particular advantage over the others, that, up to a flying angle of 45 degrees,

a constant level can be maintained in the float chamber, due to the design of the float chamber. It has an annular float and float chamber, with a rather differently constructed type of needle valve regulator, but still the principle is exactly the same as before. The jet is situated concentrically with the float chamber. The throttle barrel, which is above the float chamber and is surrounded by a hot-water jacket, has three apertures on its circumference, one for the admission of air and gas to the inside of the barrel, which has to act as a mixing chamber for the carburetor; one for the admission of extra air, and the remaining one for the admission of the mixture into the induction pipe. It will be noticed that a well-designed choke tube is fitted to this carburetor, the object of a choke tube being, in all cases, purely to intensify the suction at the mouth of the jet. This extra air intake is of additional advantage, owing to the fact that it is only utilized after the engine has obtained a certain speed, thus increasing the effi-

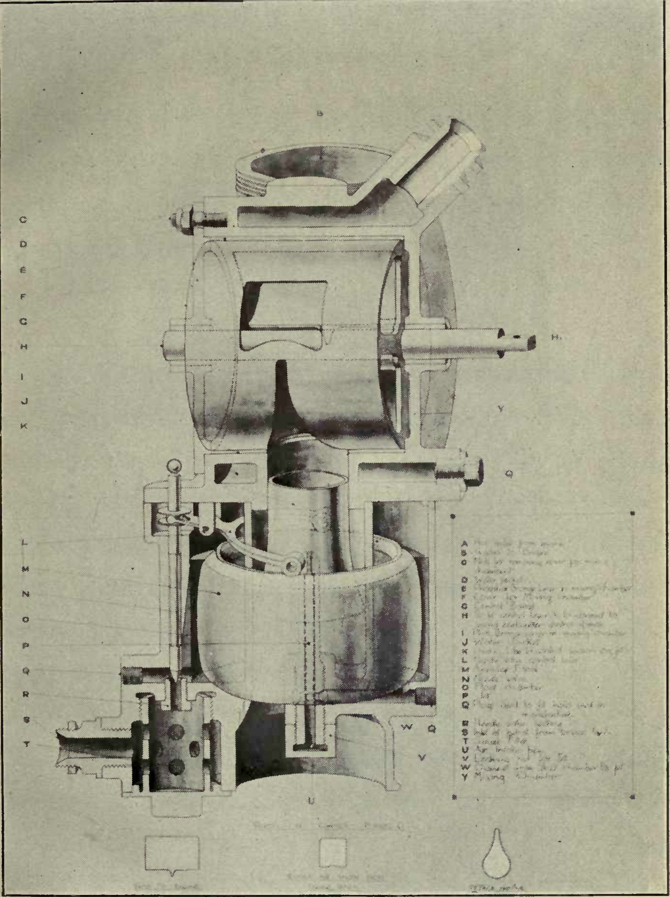

FIG. 17. — The Beardmore Carburetor.

ciency of the engine by producing a balancing effect, and lessening the intense richness of the mixture at high speeds, which, as will be shown at a later stage, is a desirable feature.

THE ZENITH

The Zenith is almost identical with the Claudel in construction. The float chamber and its component parts are the same, the chief point of divergence being the fitting of the three jets — a main jet, a compensating jet, and an auxiliary or slow running or starting jet. The fitting of this latter jet permits of the supply of a rich mixture for greater ease in starting. This carburetor is also furnished with a choke tube. The speed of the engine is regulated by a butterfly valve, which is in the form of a circular disc at the mouth of the mixing chamber.

By inspection of the section of the carburetor, it will be seen that when the throttle is in starting position (about $\frac{1}{3}$ open) the suction of the engine

is concentrated on the auxiliary jet and less suction is on the remaining two jets. When the engine is started and the throttle is gradually opened, the suction on the auxiliary jet decreases and the suction on the main and compensating jets gradually increases. The smoothness of acceleration of an engine when fitted with this carburetor is such that it is indiscernible when the engine ceases to run on the auxiliary jet and starts to run wholly on the main and compensating jets; this is a very desirable feature in the running of an engine.

NON-FLOAT TYPES

Leaving the float type carburetors, something may now be said about the carburation of rotary engines. It has often been stated that the Monosoupape has no carburetor. This statement is entirely erroneous, for it has a carburetor in every sense of the word. It is in the crankcase of this engine that the gas is first mixed with a small quantity of air. This rich mixture is again further

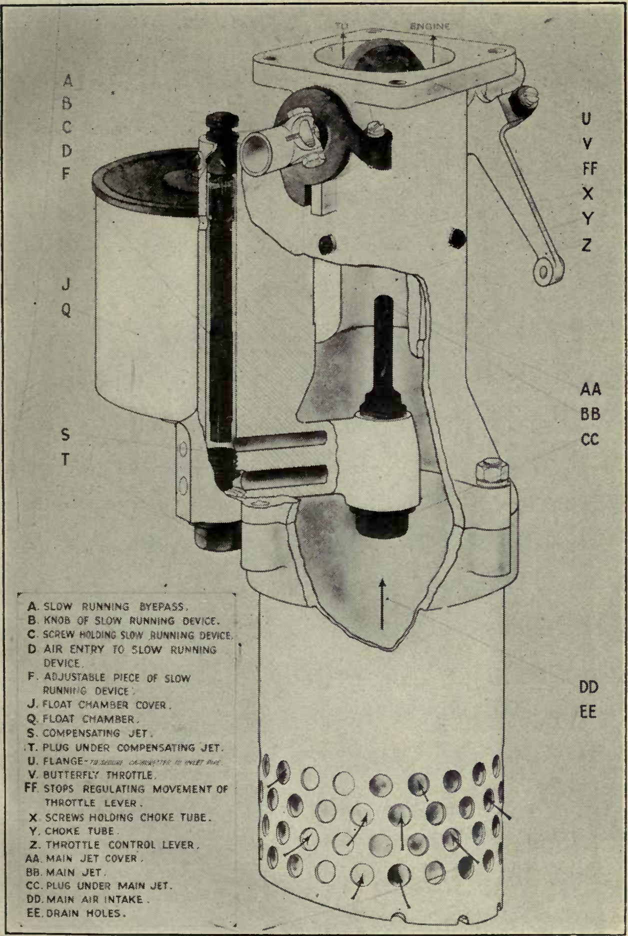

FIG. 18.—Zenith Carburetor.

diluted with air in the cylinders; thus, by every logical argument, the crankcase and cylinders of this engine function as a carburetor for it.

A very common and very largely used design of block-tube type carburetor is that illustrated. This carburetor is mounted on the end of the hollow crankshaft, which is utilized as a carrying medium for the explosive mixture to the crankcase and cylinders. Gasoline is fed from the tank through the fine adjustment valve to a horizontal jet. This jet is opposite to a throttle slide which has a taper needle attached. The needle fits inside the jet and as the throttle slide moves backwards or forwards, so the flow of petrol is increased or decreased. Drains are fitted to carry away the surplus petrol and the inside of the body is lined with gauze to act as a filter for the air intake. It is arranged in this carburetor, by designing the taper of the needle and the air aperture at the rear of the carburetor in pro ratio to one another, that for all positions of the throttle lever the mixture in the engine re-

mains in the ratio of 1 to 18. This is used on such engines as the Clerget, Le Rhone, and A. R. It is largely due to the fitting of this carburetor that these engines can be throttled down to a considerably slow speed.

EFFECT OF ALTITUDE

Before discussing the troubles of carburetors, a few remarks will be made on the effect of altitude on the carburetor and the regulation of the mixture. The higher an aeroplane goes, the richer becomes the mixture of its own accord. This is because, at various throttle positions, the mixture of gas and air is almost constant at all engine speeds. By this it is meant that the changing vacuum in the carburetor does not affect the strength of the mixture. The composition of the mixture is affected only by temperature and atmospheric pressure. As the machine ascends, the atmospheric pressure decreases, consequently the air becomes

more expanded, and the temperature is also decreased. The diminution of temperature would tend to make the air more dense and the rate at which this takes place is greater than that at which it becomes expanded, owing to the decrease in atmospheric pressure.

Experiments have been made with carburetors set correctly at sea level; when these have been taken to an elevation of approximately 7000 feet, an increase in the gasoline consumption of about 10 per cent has been noted, which has not been compensated for by the slightly added power attained by the engine through the use of a richer mixture. Therefore, it is incumbent, in the interests of efficiency and the conservation of fuel, that some provision be made to check this excessive waste at the higher altitudes. The rate of discharge of gasoline from the jet is dependent on the difference of pressure between the atmosphere in the float chamber and that surrounding the mouth of the jet. Therefore, by varying the difference

of pressure, the amount of gasoline passing through the jet will be varied also. This is what is actually done in practice, and it is accomplished by means of a suitably fitting valve which connects the mouth of the mixing chamber with the top of the float chamber, which is hermetically sealed. By opening this valve, the engine is allowed to reduce the pressure of the air in the float chamber while the pressure in the mixing chamber still remains atmospheric, thereby correcting the mixture and at the same time diminishing the flow of gasoline through the carburetor.

There is, however, one point which it is advisable to watch in connection with this altitude correction. Suppose the pilot were flying at 12,000 feet and commenced to glide down to a lower level. When the machine had reached about 3000 or 4000 feet, and the pilot wished to continue on again, necessitating the use of the engine, there would be a possibility of the engine stalling, due to a faulty mixture being supplied to the engine,

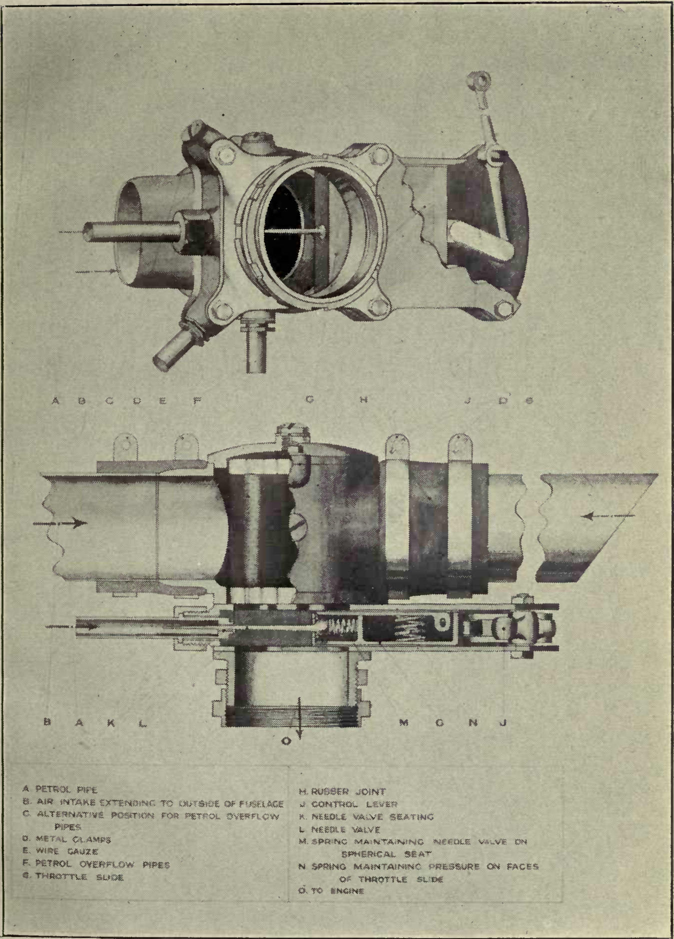

Fig. 20.—Section of Block Tube Carburetor.

if, in the meantime, the valve controlling this adjustment had not been closed.

CARBURETOR TROUBLES

Having dealt briefly with carburetors and carburation in general, the writer will take up some of the most common troubles that arise in the everyday use of the carburetor.

Flooding of the Carburetor. —

This may be due to either a punctured float or a faulty needle-valve seating. In the case of the former, it will be necessary at all times to place a new float in the carburetor. It would only be in the event of absolute necessity that the damaged float would be soldered. In the case of a faulty needle-valve seating, the repair would be effected by taking out the valve spindle and grinding it in the proper mechanical fashion. The remedy is not to seize hold of the valve spindle with a pair of pliers at the top and by sheer force grind the

valve into its seating; the repair would be very temporary and very quickly the flooding would again take place.

Partial Stoppage of the Flow of Petrol. —

This is due to the blocking of the filters and jets, usually caused by impurities in the petrol or water in the base of the filters. It is sometimes caused by using inferior rubber connections, which are affected by the discharge of the petrol, leaving small particles of rubber at the base of the filter.

Popping Back. —

Another familiar trouble is that of a series of explosions in the inlet pipe. This is commonly spoken of as "popping back" in the carburetor. The following are causes of this:

a. Weak inlet valve spring.

b. Faulty inlet valve spring.

c. Too rich or too weak a mixture.

d. Incorrect valve timing.

e. Incorrect tappet clearances.

Overheating is also caused by too rich or too weak a mixture. The reason for this is that on the power stroke, instead of the gases expanding in a gaseous state, they expand in the form of a flame, or what is commonly called "a flaming power stroke," resulting in heat.

Stoppage of Flow of Petrol. —

a. Petrol cocks not open.

b. Empty tank.

c. Needle valve jammed.

d. Jets or filters choked.

e. Water collected in the base of the carburetor. This may be from condensation, or the water may have been an impurity in the gasoline.

f. Air-bound tank in the case of a gravity-fed machine. Loss of pressure in the case of a pressure-fed machine.

TESTING CARBURATION

In closing this chapter, just a word regarding the testing of an engine for efficient carburation. It is absurd for one who poses as an amateur engineer to say that an engine has got efficient mixture. One reads in books of various tests for carburation, such as testing by a deposit on a sheet of white paper, or by noticing the flame coming through the exhaust valve, or by the colour of the smoke from the exhaust box, certain colours or deposits denoting certain strengths of mixtures. All these are very well and sound well in the ears of an amateur, but they are of no more particular use to the engineer than the paper they are written on. It is only by constant experience and intimacy with the testing of an engine that one acquires the art of saying accurately whether the carburation of an engine is efficient or otherwise. The writer strongly advises the amateur who has any trouble with the carburetor, other than those here enumerated, to

seek at once the advice of a competent mechanic, because, in endeavouring to repair the damage the amateur may, as the saying is, "Go far and fare worse."

CHAPTER FOUR

Magnetos and Ignition

In making a study of the magneto, it is necessary that one should be prepared to take a few things for granted, just as in studying Euclid it is necessary to accept certain axioms. The theory of the magneto is one chiefly of induction and it is impossible in a brief description to deal fully with this theory, and it would not be to the advantage of the student to befog his mind with the details of this very technical subject.

MAGNETISM

Before entering into the study of the magneto itself, it is requisite that the reader should have a little knowledge of Magnetism, which is, of course, the fundamental source of energy in the magneto.

Magnetism can be produced in any iron or steel bar. Take a section of unmagnetized iron or steel and place it under the microscope and it will be noticed that the particles of metal are arranged in most hopeless confusion. Now magnetize it, and the fibres of metal become arranged with per-

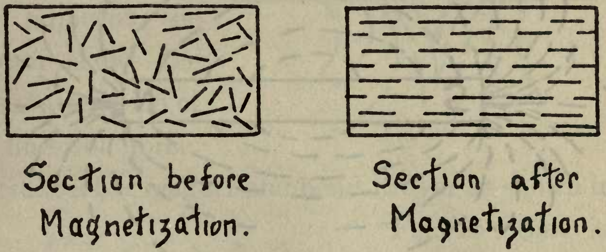

Fig. 21.

fect symmetry. Each particle becomes in itself a small magnet with a north and south pole, the whole combining to make one magnet with one north and one south pole. This will be clearly understood by inspection of the accompanying diagram (Fig. 21).

The magnetizing of a piece of metal has also an effect on the surrounding space. Take a bar

magnet and place it under a sheet of paper or glass, then sprinkle iron filings on the top. Tap the paper and the filings will take up a definite formation around the magnet, forming "lines of magnetic

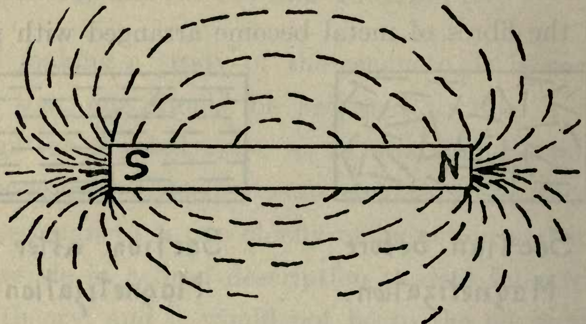

FIG. 22. — Diagram illustrating Lines of Magnetic Force radiating from a Bar Magnet.

force." The space which they permeate is known as a "magnetic field."

It is from a field of magnetic force that the initial or primary current in the magneto is derived. There are certain definite laws that govern magnetism. Unlike poles attract and like poles repel. This is readily understood by reference to the

diagrams. Diagram 23 shows two like poles adjacent and illustrates the repulsion, very few lines of force passing between the poles. In the next case, with unlike poles adjacent, the diagram shows the mutual attraction of the lines of force.

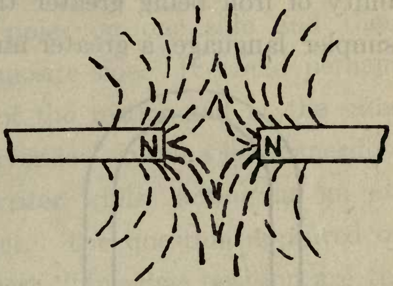

FIG. 23.

Now take a bar magnet and bend it over as shown in Fig. 25; that is, roughly into the shape of a horseshoe, and in between the ends of the magnet a field of force will be produced. In order to make the field of force as strong as possible, what are known as pole pieces are placed on the

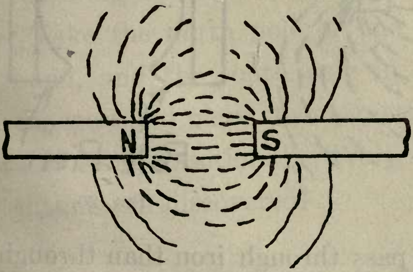

FIG. 24.

feet of the magnets, as shown in Diagram 26. These pole pieces are made of very soft iron, the permeability of iron being greater than that of steel; in simpler language, a greater number of lines of force

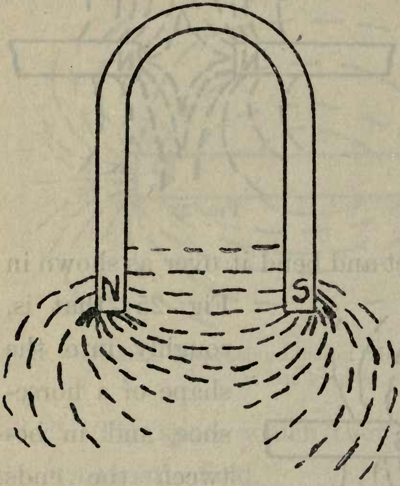

Fig. 25.

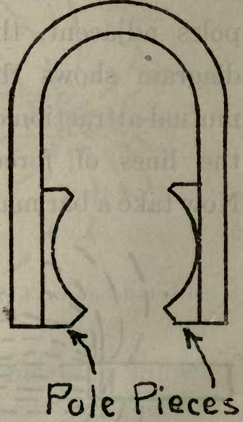

Fig. 26.

per square inch will pass through iron than through steel. Therefore, the pole pieces increase the strength of the field between the poles, and the efficiency of the magneto is increased accordingly.

In some magnetos the field of force is produced by two bar magnets in lieu of one, these being placed side by side on the frame of the magneto, having their north poles on one side and their south poles on the opposite side. It would perhaps add to the interest of the reader and at the same time make a slight diversion to tell a little anecdote that came to the writer whilst acting as an examiner in this subject. The question appeared on the examination paper: "In what position are the magnets placed on the frame of a magneto?" The following lucid answer was among those given: "Take the north pole of one magnet in the right hand, and the south pole in the other hand, face the west and place the magnets on the magneto in the same position." Truly a new principle of magnetism discovered!

PRINCIPLE OF WINDING

On the armature in any magneto, there are to be found two windings; a primary, consisting of a

few turns of moderately thick wire, and a secondary, consisting of a large number of turns of exceedingly fine wire.

The principles underlying the production of the currents in the various windings are as follows. The principle governing the Primary circuit is this: If any coil of wire is caused to rotate in a magnetic field, a current of electricity is produced in that coil. This might be expressed that if lines of magnetic force are cut by a coil of wire, then a current of electricity is generated in that coil. In Figure 27 a coil of wire is shown connected to a galvanometer, and a bar magnet pushed towards the coil as shown by the arrow; when the lines of force cut the coil of wire,

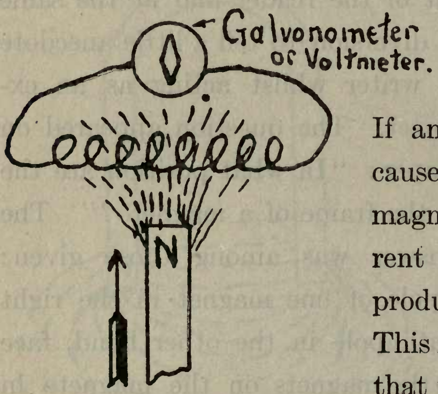

FIG. 27.

there is a momentary deflection of the needle, showing the presence of a current in the coil. It is only in the act of cutting that this current is produced.

From a coil of wire through which a current of electricity is flowing, there will be a radiation of

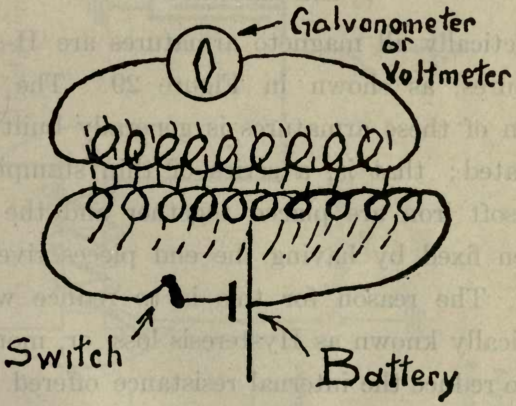

FIG. 28.

lines of force. It is by cutting these lines of force with another coil of wire, insulated from it, that a current of induction is produced.

The principle underlying the Secondary is, that if a coil of wire charged with electricity be inserted

inside another coil of wire, and the lines of force from the inner coil cut the windings of the outer coil, then a current of electricity is induced in the outer coil. This is demonstrated in Figure 28.

THE MAGNETO

Practically all magneto armatures are H-section armatures, as shown in Figure 29. The centre section of these armatures is generally built up or laminated; that is, a series of thin stampings of very soft iron are placed together and the whole is then fixed by having the end pieces riveted to them. The reason for this is to reduce what is technically known as Hysteresis loss, or, more simply, to reduce the internal resistance offered to the lines of magnetic force through the armature. One end of the primary winding is attached to the armature core and a few turns made around the core, the other end being led to one of the points on the contact breaker. The other platinum point on the contact breaker is earthed by means of a

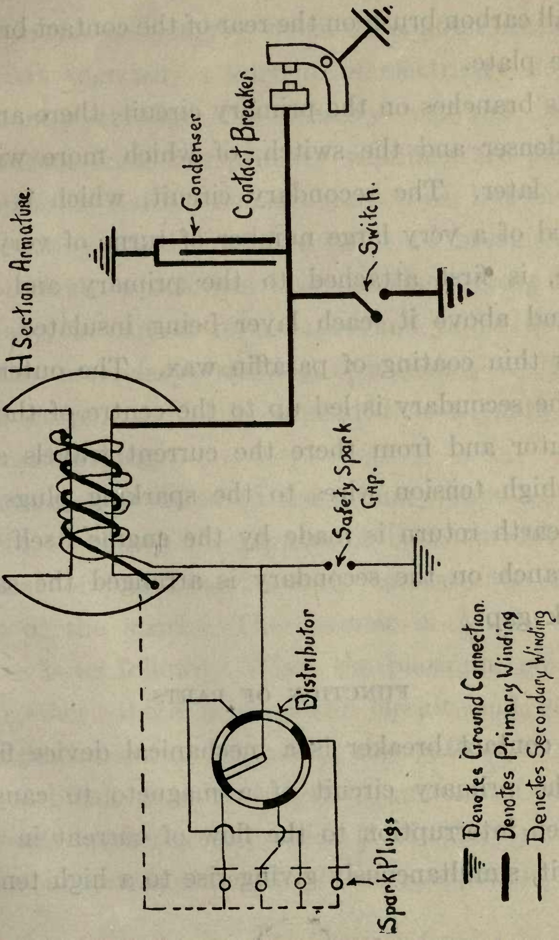
H Section Armature.
Condenser
Contact Breaker.
Switch.
Safety Spark Gap.
Distributor
Spark Plugs
Denotes Ground Connection.
Denotes Primary Winding
Denotes Secondary Winding

FIG. 29.

small carbon brush on the rear of the contact breaker base plate.

As branches on the primary circuit, there are the condenser and the switch, of which more will be said later. The secondary circuit, which is composed of a very large number of turns of very fine wire, is first attached to the primary and then wound above it, each layer being insulated by a very thin coating of paraffin wax. The outer end of the secondary is led up to the centre of the distributor and from there the current travels along the high tension wires to the sparking plugs and the earth return is made by the engine itself. As a branch on the secondary is arranged the safety spark gap.

FUNCTION OF PARTS

A contact breaker is a mechanical device fitted to the primary circuit of a magneto to cause a sudden interruption to the flow of current in that circuit, simultaneously giving rise to a high tension

current in the secondary. When the contact breaker points are together, a current of electricity flows permanently through the primary windings, and lines of force from the primary windings are passing constantly across the secondary coils, but there is no cutting effect. At the point of break, the field of force, which has been passing across the secondary, is caused to collapse and in so doing cuts the secondary winding, producing a high tension current, which is expended as a spark at the sparking plug.

A condenser is fitted to the primary circuit of a magneto to absorb the reverse or back current at the point of break, and also to increase the efficiency of the spark. The manner in which this operates is as follows: When the platinum points are together, there is a closed circuit and electricity flows continuously along this path. At the point of break there is a certain amount of electricity left in the circuit, which if left there would produce a certain amount of heat, which would

probably detrimentally affect the insulation of the windings. This electricity is absorbed by the condenser and when the points come together again this energy is given back to the primary winding, thus increasing the strength of the current in that circuit, and also increasing the strength of the spark. The condenser is composed of sheets of tin, interleaved with sheets of mica, and can be said to function as a storage battery for the primary circuit, and not as the mixing chamber to the carburetor, an indignity which it has suffered in the minds of more than one aspirant to magneto fame. The switch is fitted purely to short circuit the primary circuit, or, in other words, to provide a direct and permanent path for the current to flow to earth, thus preventing a possibility of a spark occurring at the plug.

The safety spark gap, which is found on the secondary circuit, is, as its name implies, a safety device fitted so that in the event of any unforeseen obstruction to the flow of current arising in the

secondary, a spark can occur at the gap and thus prevent the windings of the secondary from being burnt out. (Not — as a student thought — in the form of a steel plate in between the petrol tank and the engine to prevent sparks from the engine setting fire to the petrol tank.) By an obstruction is meant such an event as a plug becoming sooted up or oiled up, or a high tension lead dropping off.

The above description will serve to give the reader a rough idea of the internal workings of a magneto, and will form a foundation for him to work on in a more detailed study.

THE SPARKING PLUG

The sparking plug, as has already been explained, is fitted for the purpose of exploding the gases in the cylinder. In construction it consists of a metal shell or barrel made perfectly gastight by means of suitable packing, an insulated core of porcelain or mica through the centre of which passes a rod terminating at one end in what is called a sparking

point or an electrode, this being the inner end. The other, or outer end, is fitted with a terminal to which is attached a high tension lead from the distributor. The actual designs of sparking plugs vary to suit individual manufacturers' ideas and circumstances.

MAGNETO TROUBLES

If it were possible to make an analysis of all magneto troubles, it would be found that over 90 per cent of them were contact breaker troubles. First, there is sticking of the rocker arm, due to moisture; this can be remedied by removing the arm and easing the fibre bush on which it rocks, by the aid of a small reamer. On no occasion must oil be used to free this.

Another trouble is sparking at the platinum points. This may be due to condenser failure or pittedness of the points. By pittedness is meant that the surface of the points has become broken up, due to what is known as local action. This

cannot be avoided and will occur on any magneto, however well it may be cared for. In setting the points again, it must be remembered that the standard setting is to allow a gap of .020″ between the points when fully open.

Many are the troubles that have been caused by overlubrication. It is a great mistake, which amateurs are prone to make, and should be avoided at all costs. Its effects are such troubles as oily carbon brushes, distributors, slip-rings,—all of which act as a short circuit. Faulty contact may also be caused by the springs being weak, due to excessive wear on the brushes.

Trouble is also experienced with the sparking plug in the shape of faulty insulation, excessive sooting up, due to either inferior fuel or over-rich mixture, or overlubrication. Too small or too wide a gap at the points may also be found a source of trouble.

It may be of interest to state exactly at what point the armature is when the contact breaker

is caused to open. Figure 30 shows the armature in the point of maximum efficiency. Figure 31 shows it in the vertical position. It is when the armature changes from Figure 30 to position in Figure 31 that the contact breaker is opened.

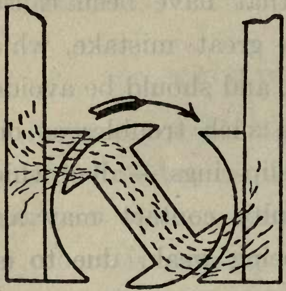

FIG. 30.

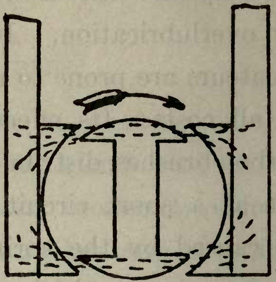

FIG. 31.

The reason for this is that in the former position the maximum number of lines of force are being cut, thereby generating the maximum current.

There are only two types of magnetos in use to-day, although there are scores of different designs. The theory of them all is exactly the same, and all of the above remarks and all the preceding

diagrams can be applied with perfect safety to any of them. The types are: a rotating armature type which gives two sparks per revolution of the armature, and a rotating shield type or stationary armature which gives four sparks per revolution of the shield. This gives a spark every time the trailing edge of the shield leaves the corner of pole piece, as shown. This shield is made of very soft iron.

In conclusion, it would perhaps be as well to mention the object of using two sparking plugs in one cylinder. It, of course, quickens the rate of combustion and increases the force of explosion, thus increasing the power of the engine. To think that by placing an extra plug in the cylinder in a haphazard fashion will give an increase of power is to make a very serious mistake. Great discretion is necessary in the placing of the two plugs. They must be situated in parts of the cylinder where the gas surrounding their points is as nearly as possible of the same strength and proportion. The two

plugs must also be perfectly synchronized so that the plugs spark simultaneously. Unless these points are very closely observed, no good can accrue from the use of two plugs.

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